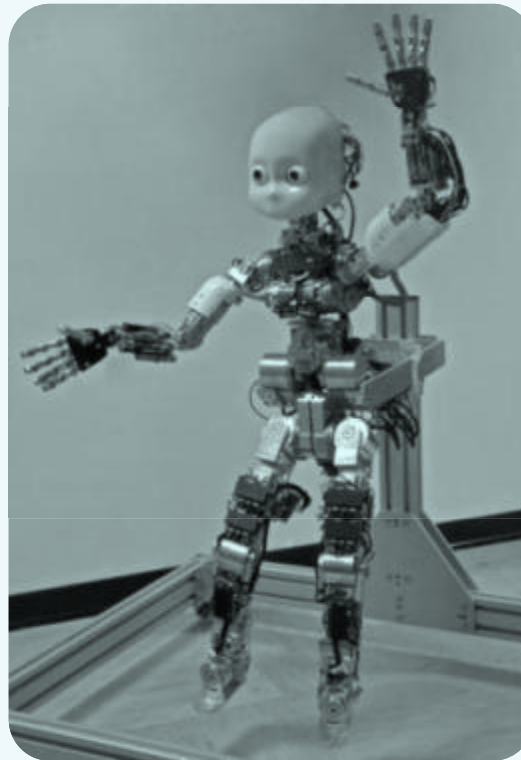


# The iCub humanoid platform



Giorgio Metta  
Sestri Levante, July 21<sup>st</sup>, 2008  
Italian Institute of Technology

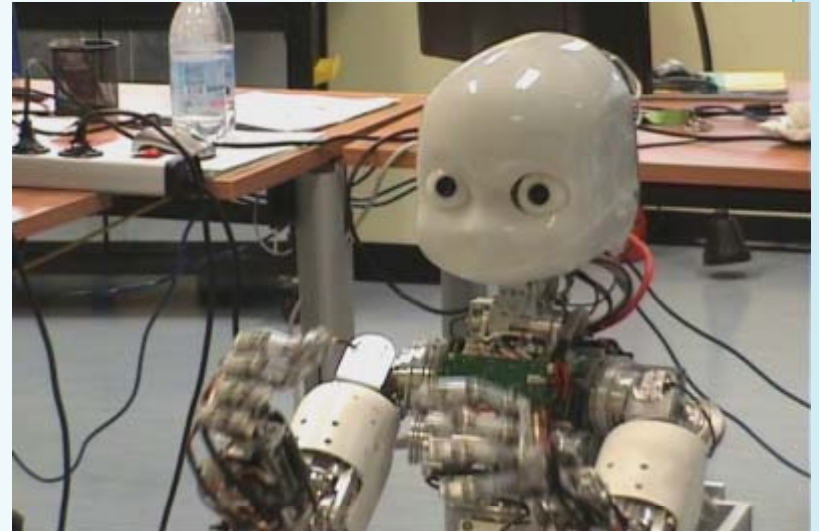
# The iCub: quick summary

The **iCub** is the humanoid baby-robot designed as part of the **RobotCub** project

- The iCub is a **full humanoid robot** sized as a three and half year-old child.
- The total height is **104cm**.
- It has **53 degrees of freedom**, including articulated hands to be used for manipulation and gesturing.
- The robot will be able to **crawl and sit** and autonomously transition from crawling to sitting and vice-versa.
- The robot is **GPL/FDL**: software, hardware, drawings, documentation, etc.

# Degrees of freedom

- Head: vergence, common tilt + 3 dof neck
- Arms: 7 dof each
  - Shoulder (3), elbow (1), wrist (3)
- Hands: 9 dof each ► 19 joints
  - 5 fingers ► underactuated
- Legs: 6 dof each
  - Hip (3), knee (1), ankle (2)
- Waist: 3 dof

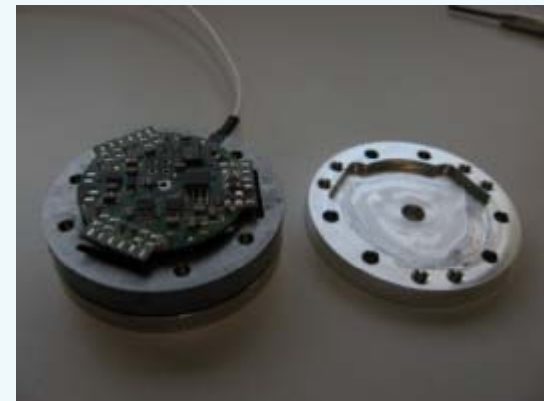
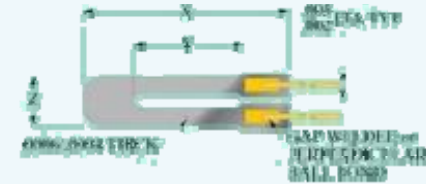


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$$\Sigma = 53 \text{ dof} \quad (\text{not counting the facial expressions})$$

# Sensorization

- For each joint:
  - Position (some absolute, some incremental):
    - Magnetic absolute position sensors
    - Encoders
    - Hall-effect sensors
  - Torque/tension
    - Limb level, but work in progress to add joint level torque sensing
    - Current consumption
  - Temperature (monitor, safety)
    - Safe operation (but we have a disclaimer now!)



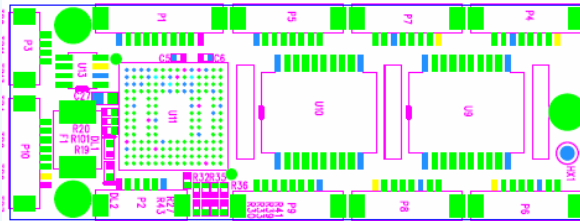
# In addition...

- Cameras
- Force/torque sensors
  - Developed: not used yet
- Microphones, speaker
  - Pinnae
- Gyroscopes, linear accelerometers
- Design of the shell, wiring, power supply, additional sensors...
  - Ongoing
- Tactile sensors, skin...
  - Low-resolution version, fingertips (more later)
- Impact, contact, sensors (e.g. for crawling)
  - TBD, can be used in combination with the force/torque sensor

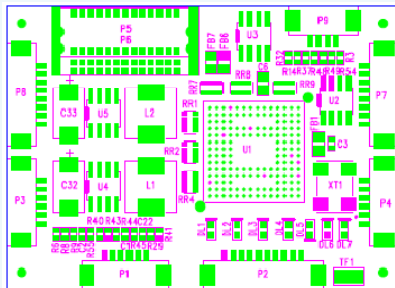


# Custom electronics

- ADC card
  - Special connectors (40 pins < 1cm length)
  - 200µm stainless steel wires, coated in Teflon
- Motor control
  - C programmable DSP 40 MIPS
  - Up to 4A DC motor



80x30mm



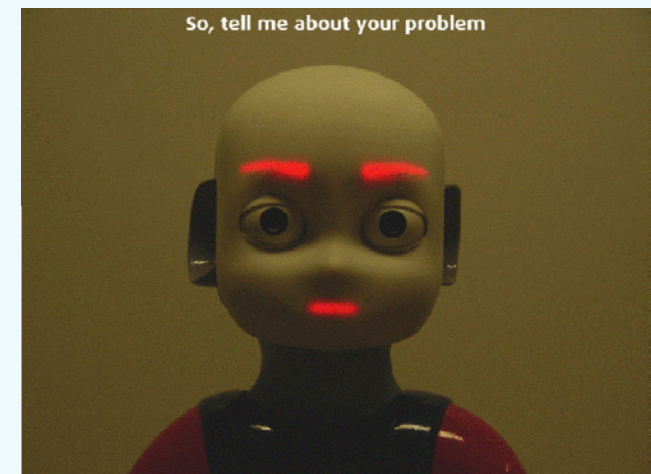
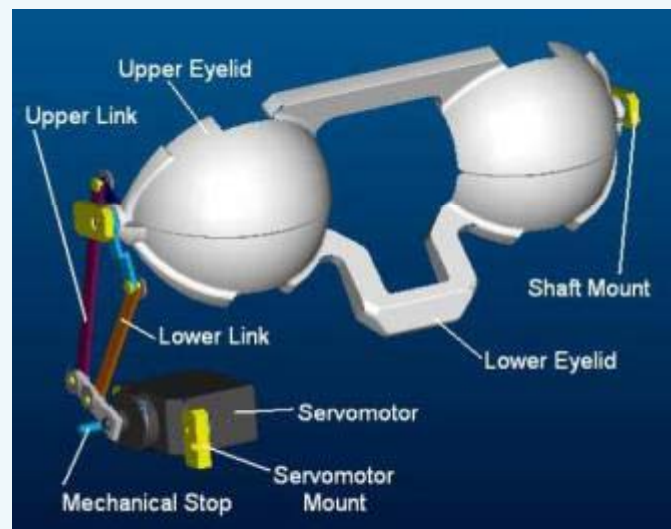
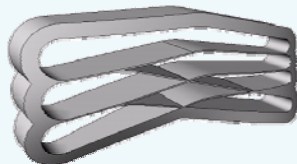
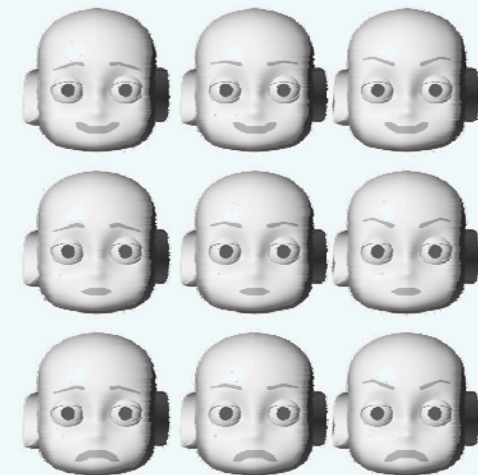
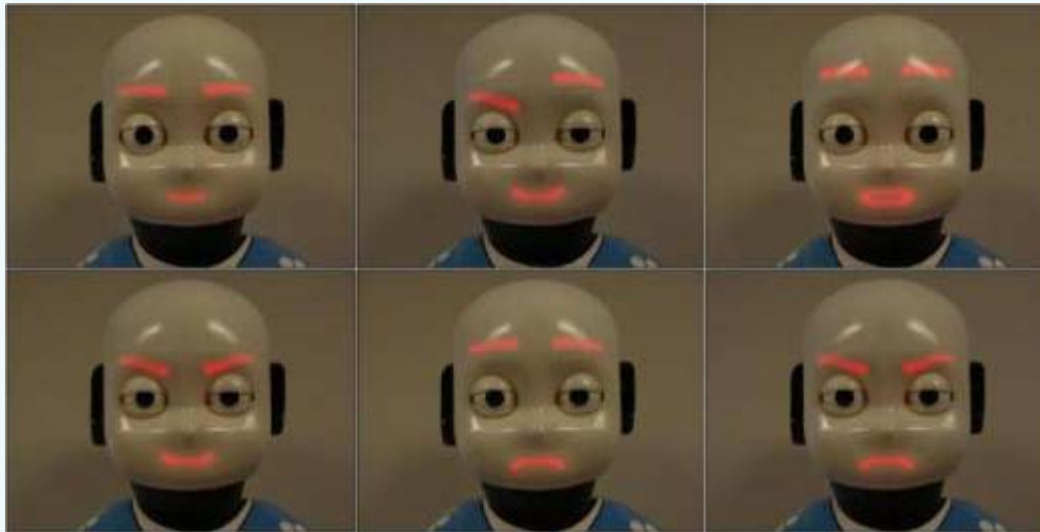
58x42mm



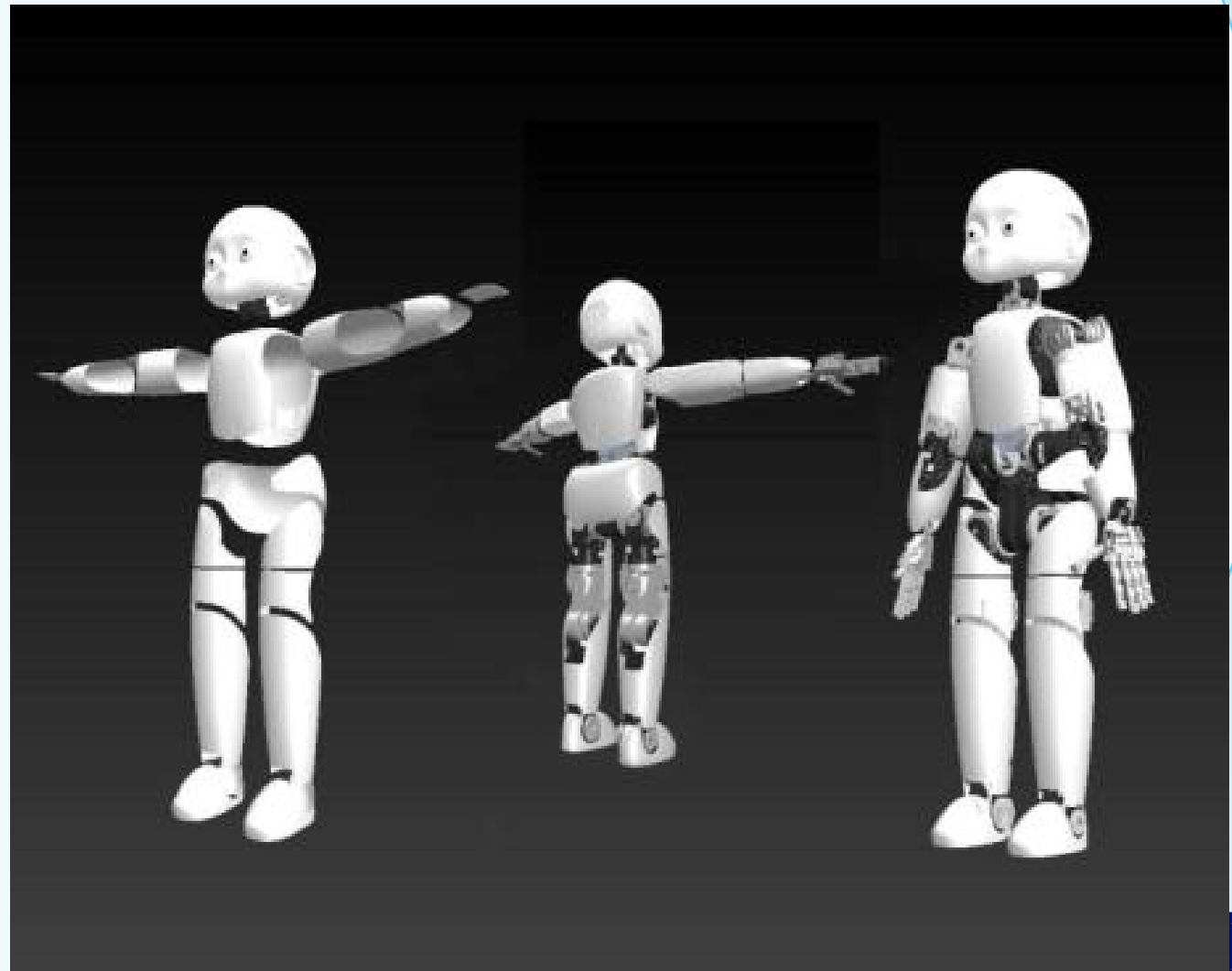
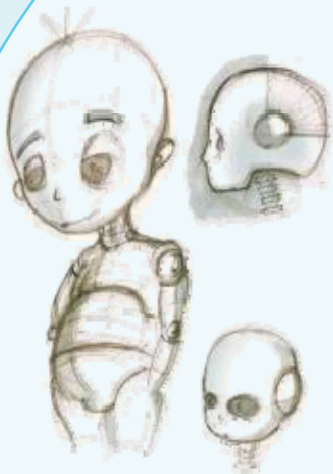
Motorola DSP56F807 (5680x family)  
 MAC instructions  
 PWM generation  
 ADC  
 Digital I/O  
 Can bus  
 C programmable



# Facial expressions

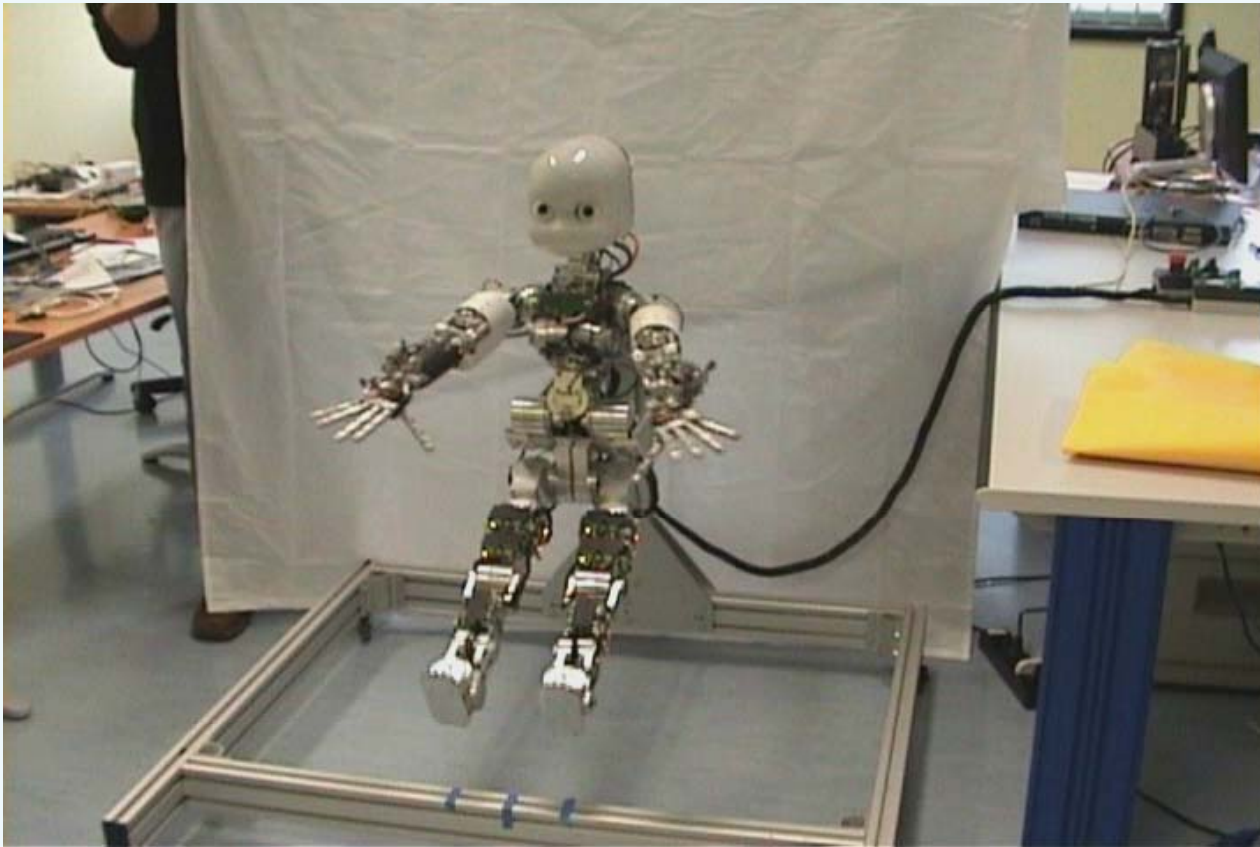


# Body cover: concept





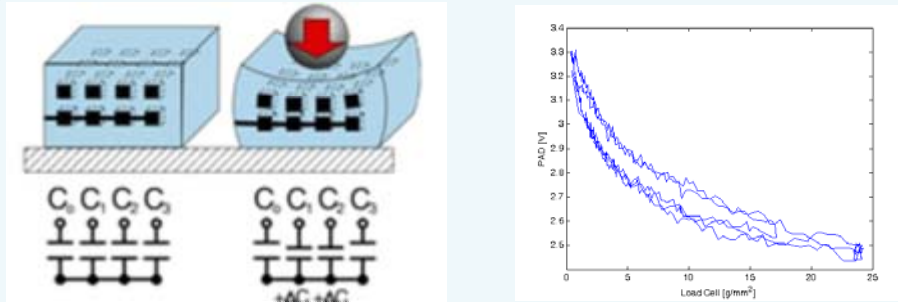
# The robot yoga!



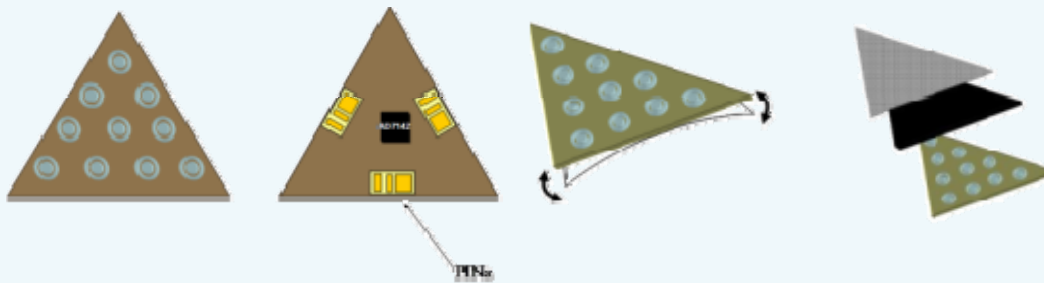
Preprogrammed movements with collision limits

# The skin

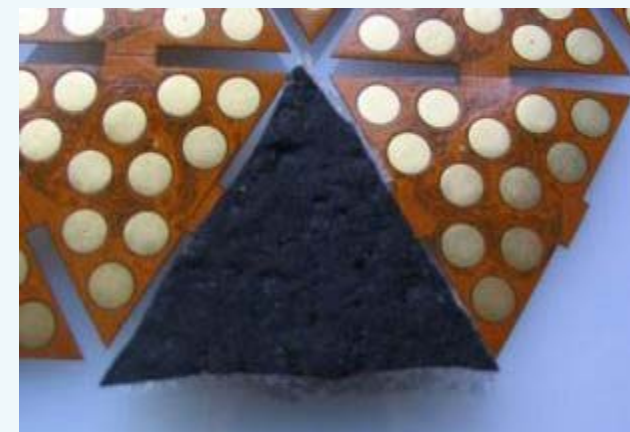
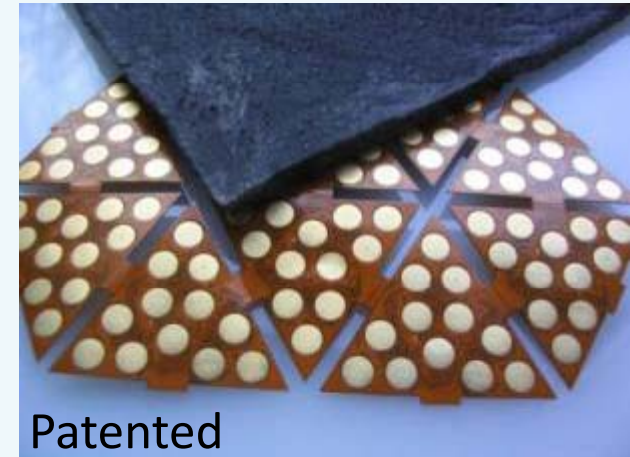
## Principle

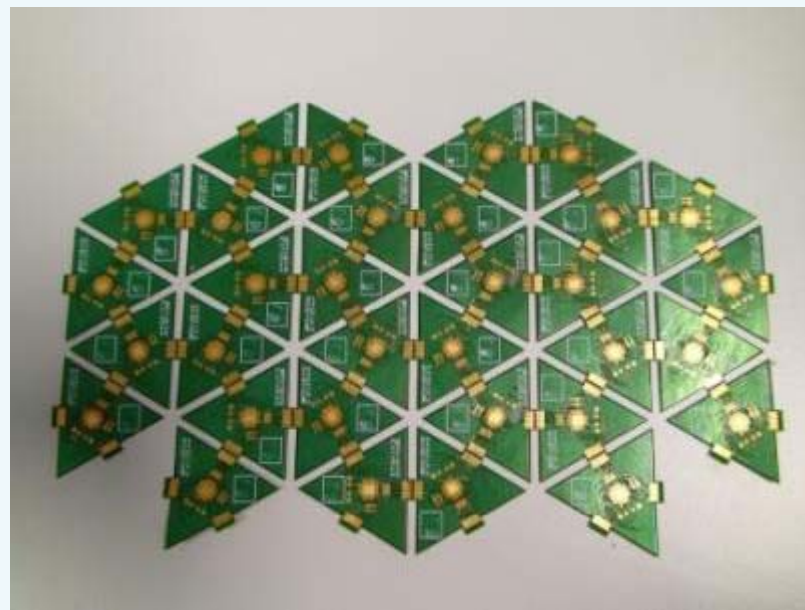
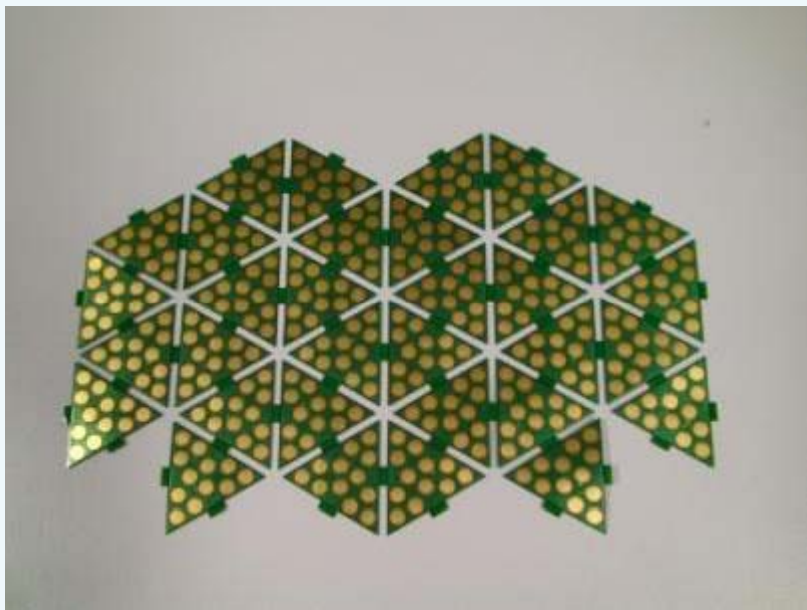


## Lot of sensing points

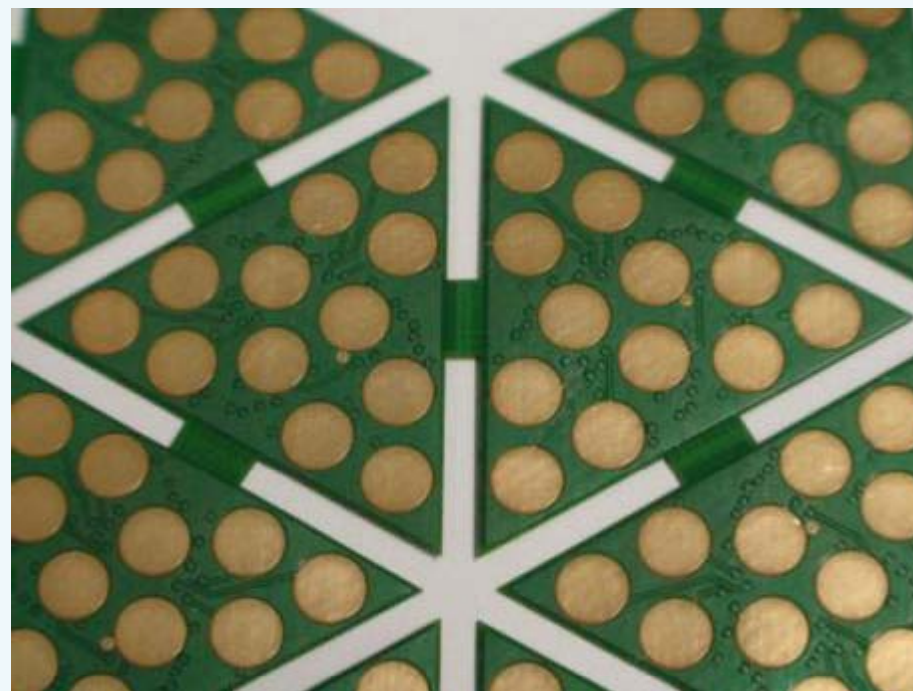
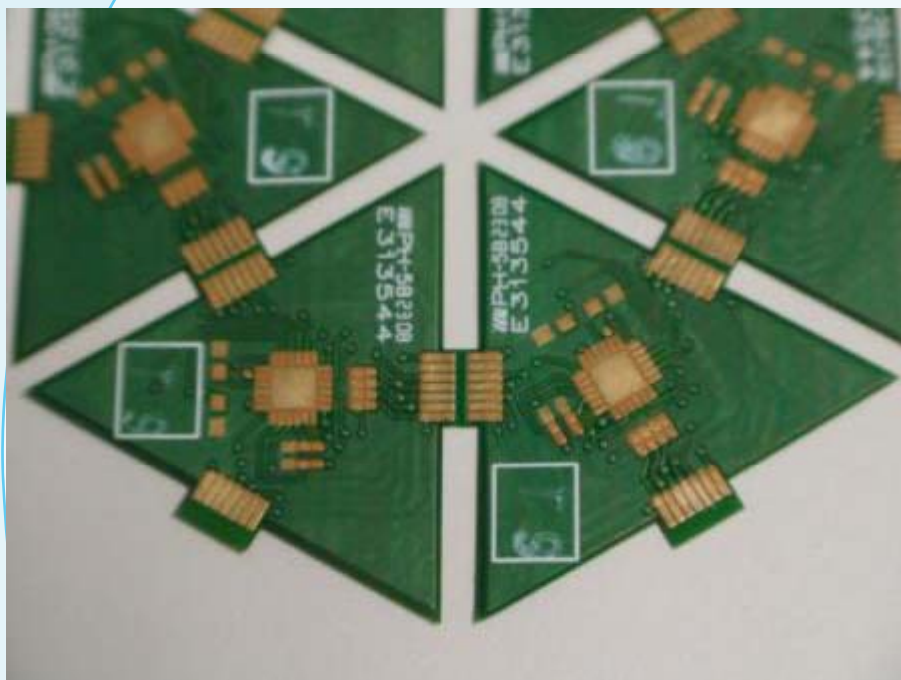


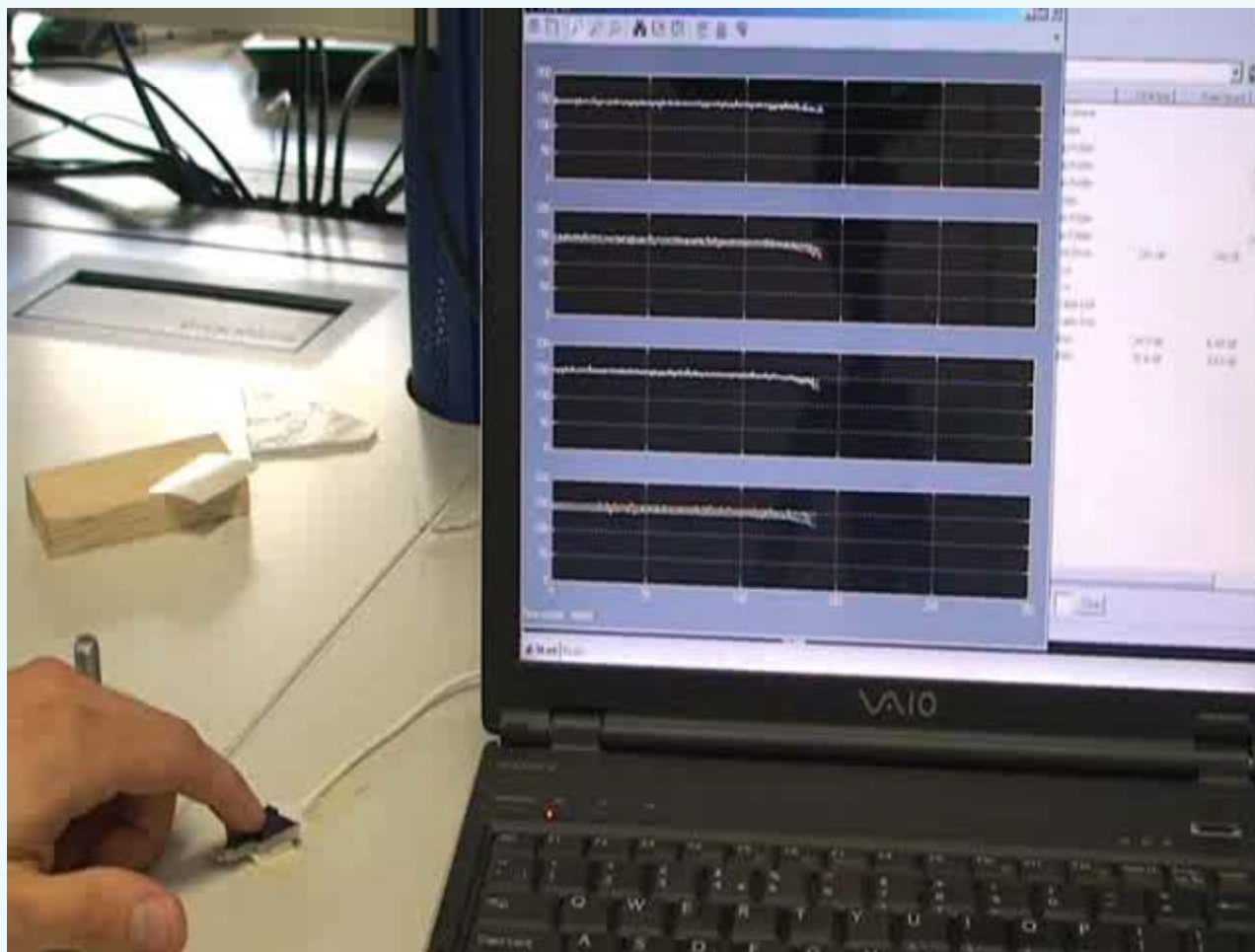
## Structure of the skin





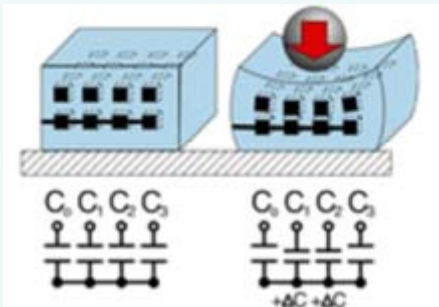




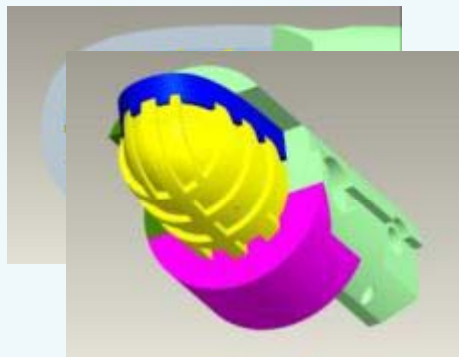




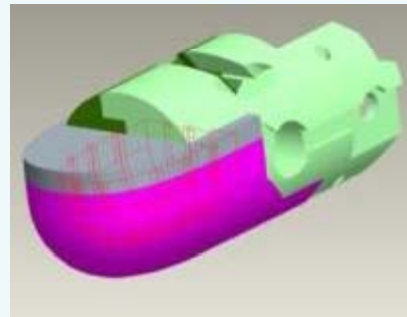
# Fingertip



Outline



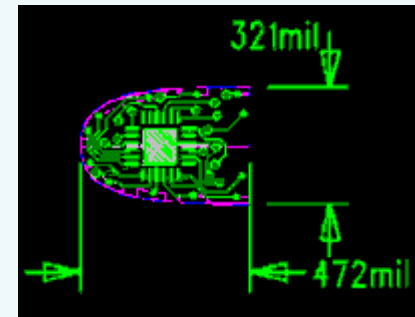
3D CAD



Silicon cover



Electrode fabrication



Electronics



Complete prototype

# 6-axial force/torque sensor



- Semiconductor strain gauges
- On board signal conditioning, sampling, and calibration
- Digital output: CAN bus

By Nikos Tsagarakis and Darwin Caldwell  
Electronics: Claudio Lorini

# Some results

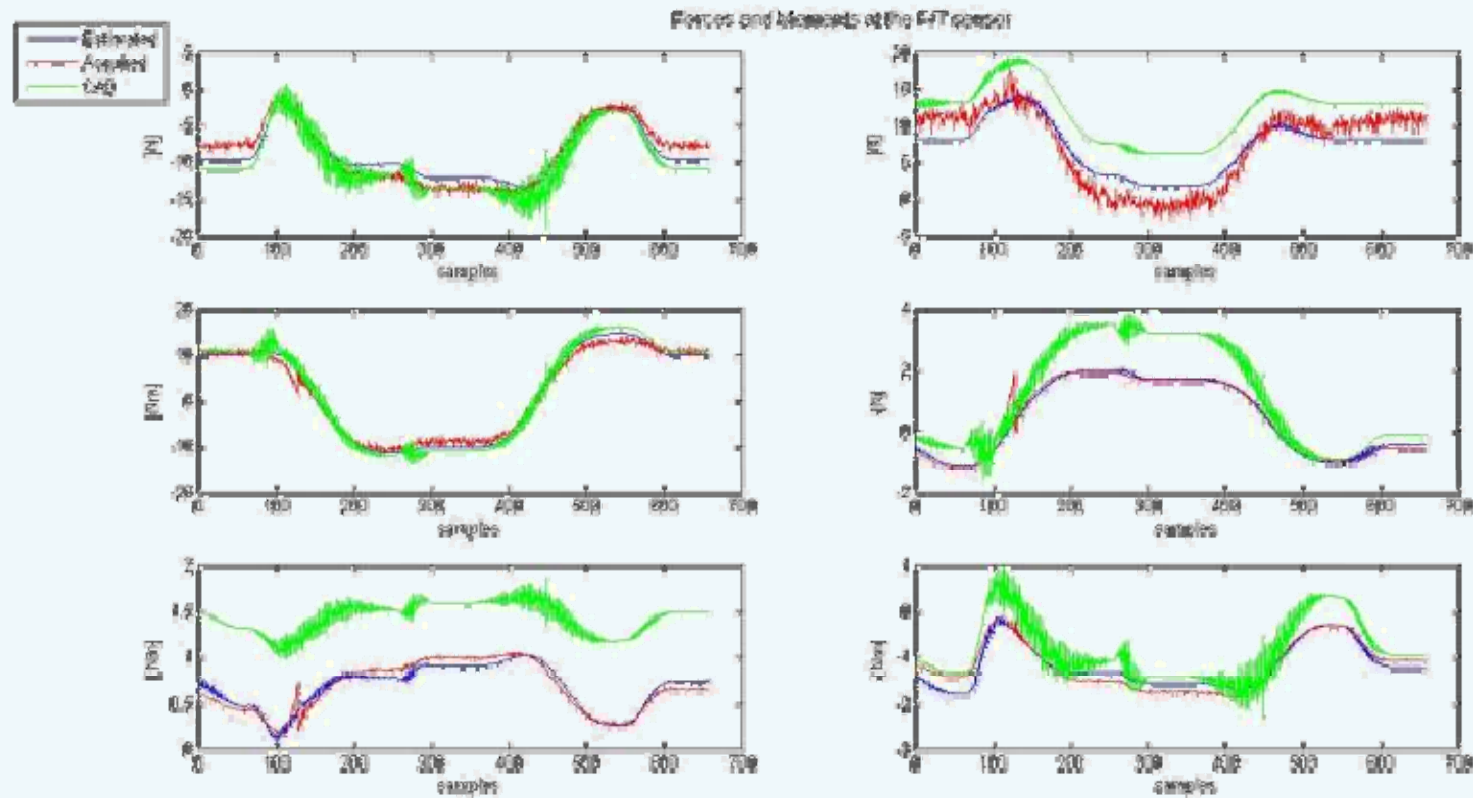


Figure 2: forces and moments measured, calculated and estimated during free motion.

**Model and parameters identification algorithm + validation**



Wiki interface showing the 'Manual' page. The page title is 'Manual'. Below the title, it says 'This is a tentative table of contents for what should be in the iCub manual. Please do not edit these pages at this point.' The page has a navigation sidebar on the left with links like 'Main Page', 'RobotCub Website', 'VW 07', 'YARP', 'Recent changes', and 'Help'. The main content area shows a table of contents with sections like '1. Hardware of the iCub', '2. Troubleshooting of the hardware', '3. Calibration', '4. Protocols', '5. Kinematic', '6. Software', '7.7. Software', '8.8. Software', '9.9. Software', '10.10. Standard', '11.11. Guideline', and '12.12. Document'.

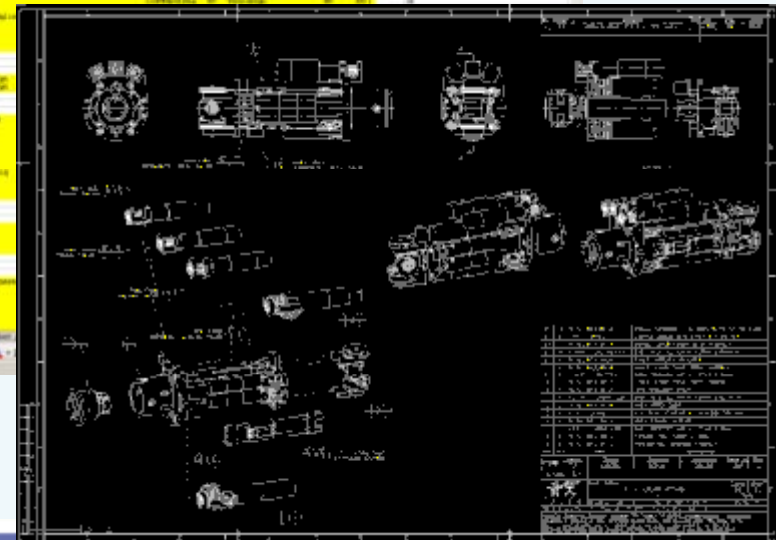
Wiki

CVS

Part lists

Drawings

Technical drawing software interface showing a 3D model of a robot arm and a table of parts. The table has columns for Name, Ext, Rev., Option, Encoding, and State. The parts list includes items like 'led', 'lowerbody', 'cabling', 'mechanics', 'electronics', 'legs', 'torso', 'bom', 'mc4', 'mcp', 'pc104', 'serial\_dsp', 'tools', 'trail', 'upperbody', 'cabling', 'mechanics', 'elbows', 'forearms', and 'bom'.



# Promoting the iCub

- RobotCub Open Call
  - 31 participants, 6 winners will receive a copy of the iCub free of charge
- Further development
  - FP7 project ITALK: 4 iCub's will be built, language
- Collaborations
  - Univ. of Karlsruhe: new and longer legs
- Simulator







⋮

Level 2 APIs: Prospective Action Behaviors

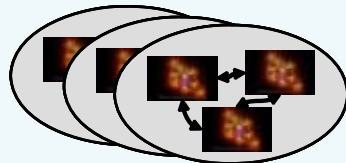
Coordinated operation: Ontogenic Development

Level 1 APIs: perception/action behaviors

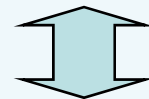
Innate perception/action primitives  
loose federation of behaviors

own  
learning  
model

Level 0 APIs: data acquisition & motor control



Multiple YARP processes  
Running on multiple processors



Gbit Ethernet

pc104: Yarp also here → HUB



Sensors & Actuators

Cognitive  
Architecture

Software  
Architecture

YARP:  
Middleware

iCub  
Embedded  
Systems

# People

- Lorenzo Natale, Francesco Nori: Software, testing, calibration
- Marco Maggiali, Marco Randazzo: firmware, DSP libraries, tactile sensing
- Francesco Becchi, Paolo Pino, Giulio Maggiolo, Gabriele Careddu: design and integration
- Gabriele Tabbita, Walter Fancellu: assembly
- Nikos Tsagarakis, William Hinojosa: legs and spine, force/torque sensors
- Bruno Bonino, Fabrizio Larosa, Claudio Lorini: electronics and wiring
- Luciano Pittera, Davide Dellepiane: wiring
- Mattia Salvi: CAD maintenance
- Alberto Zolezzi: managing quotes, orders and spare parts
- Giovanni Stellin: hand
- Ricardo Beira, Luis Vargas, Miguel Praca: design of the head and face
- Paul Fitzpatrick & Alessandro Scalzo: software middleware
- Alberto Parmiggiani: joint level sensing
- Alexander Schmitz: fingertips
- Nestor Nava: small Harmonic Drive integration
- Ravinder Dahiya: FET-PVDF tactile sensors
- Lorenzo Jamone: fingertips
- Daniel Roussy: construction
- Ludovic Righetti: simulation and initial torque specification



